HHS Public Access

Author manuscript

Soc Sci Med. Author manuscript; available in PMC 2022 September 01.

Published in final edited form as:

Soc Sci Med. 2021 September ; 285: 114307. doi:10.1016/j.socscimed.2021.114307.

Momentary loneliness among older adults: Contextual differences and their moderation by gender and race/ethnicity

Ellen Compernolle, PhD[a], **Laura E. Finch, PhD**[a], **Louise C. Hawkley, PhD**[a], **Kate A. Cagney, PhD**[b]

[a]NORC at the University of Chicago, 1155 E. 60th Street, Chicago, IL 60637

[b]University of Chicago, 1126 E. 59th Street, Chicago, IL 60637

Abstract

Rationale: Studies suggest that loneliness is associated with age. Among older adults, women and Black adults may be at greater risk than men and White adults, respectively. Social and physical contexts are also linked with loneliness. However, little is known about whether and how those of different genders and racial/ethnic groups may experience social and physical contexts differently in terms of their real-time loneliness, and the extent to which these differences may be explained by differential exposure or reactivity to contexts.

Objective: We examine (1) how momentary loneliness relates to (a) gender and race/ethnicity and (b) social and physical context; and the extent to which gender and racial/ethnic groups may be (2) differentially exposed to loneliness-related contexts and/or (3) differentially reacting to these contexts.

Methods: Using multilevel regressions, we analyzed ecological momentary assessments from 342 community-dwelling U.S. older adults from the Chicago Health and Activity Space in Real Time study. In each of three waves of data collection, smartphone "pings" (five per day for 21 days; n=12,793 EMAs) assessed loneliness, social context (e.g., alone, with a spouse/partner), and location/physical context (e.g., home, at work).

Results: Men consistently reported greater loneliness intensity than women, including after adjusting for momentary physical and social context. Older adults momentarily outside the home and/or not alone were less likely to feel lonely than their counterparts. However, the protective effect of being outside of the home (vs. home) was weaker among women and Black and Hispanic older adults, and the protective effect of being with one or more others (vs. alone) was weaker among women.

*Correspondence concerning this article should be directed to Ellen Compernolle, NORC at the University of Chicago. Compernolle-Ellen@norc.org. Telephone: (773)256-6025.

Author contributions: E. Compernolle and L. E. Finch cleaned the data and wrote the manuscript. E. Compernolle performed all statistical analyses. All authors aided in interpretation of findings and edited and approved of the final manuscript.

The authors do not have any conflicts of interest to declare.

Conclusions: Results are among the first to identify contextual effects on real-time loneliness in older adults and how these associations vary by gender and race/ethnicity. Knowledge regarding momentary variation in loneliness may inform future just-in-time adaptive loneliness interventions in older adulthood.

Keywords

ecological momentary assessment; location; social context; older adults; gender; race/ethnicity; loneliness

Introduction

Loneliness is an aversive experience that accompanies a perceived discrepancy between desired and attained social relationships (Peplau & Perlman, 1982). It is distinct from social isolation—an objective state of having minimal social contact with others. Notably, loneliness is a well-established risk factor for broad-based morbidity and mortality in older adulthood (Ong et al., 2016)—including depressive symptomology, physical health, and functional limitations (Cacioppo et al., 2014; National Academies of Sciences, Engineering, and Medicine, 2020).

Given these implications for health, researchers have sought to understand who experiences loneliness and under what circumstances. Regarding the former (*who*), studies suggest that loneliness is non-linearly related to age, increasing in adolescence and again in late adulthood after age 75 (Hawkley et al., 2019; Luhmann & Hawkley, 2016). Other studies suggest that women and those with lower educational attainment are also at increased risk for loneliness (Fokkema et al., 2012; Hawkley et al., 2019). In addition, loneliness may be higher among Black versus White older adults (Hawkley et al., 2019). Scholars (Taylor & Nguyen, 2020) have posited that higher rates of certain socioeconomic (e.g., poverty, gentrification) or social experiences (e.g., lower rates of marriage, higher rates of divorce and separation) among Black older adults may increase their risk of experiencing loneliness relative to White older adults. Regarding the latter (*when*), studies have examined the role of individuals' social and physical context, linking, for example, robust social networks and lower neighborhood disadvantage with lower risks for loneliness and related mental health outcomes (Kim, 2010; Larson, 1990; Stevens & van Tilburg, 2010; Wu et al., 2020).

Related bodies of literature have moved beyond demographic characteristics and examined how dimensions of social and physical context shape individuals' risk of loneliness.Regarding social factors, studies have found lower levels of loneliness among individuals with more frequent contact with friends (Finlay & Kobayashi, 2018; Pinquart & Sorensen, 2001; Stevens & van Tilburg, 2010), more frequent sibling contact (Dugan & Kivett, 1994), greater emotional connection to children (Long & Martin, 2000), and among those who are married (Hawkley et al., 2020; Stack, 1998). Physical context has also been associated with related dimensions of mental health and, to a lesser extent, loneliness. For example, studies have linked characteristics of key physical spaces outside the home—such as residential location (e.g., urban, rural) and/or density, neighborhood socioeconomic disadvantage, and fear of crime—with higher risk of loneliness, depression, and anxiety,

respectively (Kawachi & Berkman, 2000; Kim, 2010; Ross et al., 2001; Stafford et al., 2007).

Despite the evidence to date, little is known about how daily loneliness relates to *where older adults are* in a given moment and *whom they are with* at that time; prior studies have treated social and physical context correlates of loneliness as static individual difference variables (e.g., social network and residential neighborhood characteristics) rather than momentarily varying. The few existing studies (Larson, 1990; Wu et al., 2020) examining momentary loneliness suggest contextual factors matter (e.g., at home or alone). However, these studies do not focus on older adults, and research using ecological momentary assessment (EMAs) of loneliness remains scarce among this population, although recent studies have used EMAs to examine older adults' daily social interactions (Zhaoyang et al., 2018) and emotional state (Moore et al., 2016). It is important to examine shorter-term variation in loneliness because this permits the identification of social and physical context factors most linked with momentary loneliness—information that may guide future interventions.

Another unexplored question is whether and how those of different genders and racial/ethnic groups may experience social and physical contexts differently in terms of their real-time loneliness. Momentary context may elucidate unique sources of variation in loneliness for these groups; specifically, it may help distinguish whether documented gender and racial/ethnic differences in loneliness are driven by *differential exposure* to certain contexts (e.g., spending more time at home) or whether these groups show *differential reactivity* to these contexts. Shorter-term loneliness assessments may prove especially useful in addressing such questions. Some studies suggest that women and non-Hispanic Blacks may experience outdoor public spaces less positively than men or Whites, respectively (Yavuz & Welch, 2010; York Cornwell et al., 2019). For example, women tend to fear crime more than men, perhaps because their susceptibility to sexual assault and harassment lead them to perceive greater risk in their environments than men (Yavuz & Welch, 2010). In addition, York and colleagues (2019) suggest that lower perceptions of social cohesion among Black older adults may be a key factor related to their decreased feelings of safety in public places relative to White older adults. A better understanding of context-loneliness associations will help identify points of entry for possible interventions addressing disparate risks of loneliness across these sub-populations.

Here, we extend the loneliness literature by using three waves of EMA data from the Chicago Health and Activity Space in Real-Time (CHART) study to examine associations between older adults' momentary experiences of loneliness with their demographic characteristics and their momentary social and physical contexts. We examine three research questions, which are also represented in our conceptual model in Figure 1:

1. To what extent is momentary loneliness associated with (a) gender and race/ethnicity and (b) social and physical context (e.g., home, work)?
2. To what extent are gender and racial/ethnic groups differentially exposed to key social and physical contexts correlated with momentary loneliness?

3. To what extent do associations between context and loneliness vary across gender and racial/ethnic groups?

Methods

Sample and Study Design

The University Institutional Review Board approved all study activities. A total of 450 older adults 65 years and older living in the Chicago area were enrolled in the CHART study at baseline. Using probability-based sampling, participants were recruited from 10 different neighborhoods that were themselves selected to capture racial/ethnic and socioeconomic variation across residential and geographic areas. The CHART study was designed to describe the social and spatial environments where older adults spend their time and to characterize how these activity spaces may relate to changes in health over time across three waves of data collection spanning 18 months in 2018–2019, with waves spaced approximately 5–6 months apart.

Procedures

After informed consent, participants first completed an in-person interview, which included a baseline questionnaire assessing demographic characteristics (e.g., gender, race/ethnicity, age), household composition, and physical and mental health. Then, participants were provided with an Android smartphone (Samsung Galaxy S7, Samsung Electronics, South Korea), which they were asked to carry with them for 7 consecutive days for each wave of data collection. At the start of each wave, participants were asked to report their health, marital, and employment status. Study staff installed the MetricWire application on each smartphone prior to distribution. This app was used to administer the EMAs, such that participants were “pinged” five times per day for each of the 7 days for each wave of data collection. Each ping asked participants to report their location when they were pinged, who they were with, and the extent to which they felt various emotions, including loneliness. Following a variable schedule EMA design, the five daily pings were triggered at a random time within each of the following time windows: 8 to 10 a.m., 10:30 a.m. to 12:30 p.m., 1 to 3 p.m., 3:30 to 5:30 p.m., and 6 to 8 p.m. If a participant did not begin completing a given survey, reminder ping alerts were sent through the app at 10 and 20 minutes after the initial trigger was sent.

Measures

Socio-demographic Characteristics—Participants reported a number of socio-demographic characteristics during the baseline interview that have been linked to individuals’ risk of loneliness. *Gender* is included as a dichotomous measure. *Race/ethnicity* is a categorical measure constructed using two items: race (White; Black/African American; Asian; Native Hawaiian or other Pacific Islander; American Indian or Alaskan Native; Other) and ethnicity (Hispanic/Latino or not). Respondents were coded as non-Hispanic White (reference), non-Hispanic Black, and non-Black Hispanic; for parsimony, we hereafter refer to individuals in these groups as White, Black, and Hispanic. *Educational attainment* is included as a categorical variable: less than high school (reference), some high school, high school graduate or GED, some college but no degree, and college graduate.

Last, *age* subtracts date of birth from the date of the baseline interview; analyses include a continuous measure for age at baseline.

EMA/Ping Measures—Participants were presented with the EMA items below in either English or Spanish, depending on their self-reported language preference at baseline.

Loneliness.: Participants were asked, "Did you feel lonely?" with response options: not at all (1), slightly (2), moderately (3), very (4), or don't know. For descriptive analyses, we constructed a within-respondent mean loneliness score, which was constructed by taking the sum of all loneliness reports across an individual respondent's EMAs and dividing this by the total number of EMAs the respondent submitted.

Location (Physical Context).: Participants reported whether they were at home; at someone else's home; in transit by bus, train, subway, taxi, or car; in transit by foot; at work; or someplace else. Analyses include a categorical variable that collapses these responses: at home, in transit (any form), at work, and someplace else.

Social Context.: In a select-all-that-apply format, participants indicated who they were with from the following list of options: nobody, spouse/romantic partner, family member, friend, pet, neighbor, other, or don't know. Analyses include indicators for whether the participant was with a spouse/partner, family member, friend, pet, or other (reference: no one).

Other Key Variables.: Each EMA wave asked the respondent to self-report their physical health status on a scale from 1 (excellent) to 5 (poor) to assess change over the course of the study. We include *health status* as a categorical measure collapsing the lowest and highest most categories due to small group size: excellent/very good; good; and fair/poor. Similarly, each EMA wave asked whether the respondent was: married, living with a partner, separated, divorced, widowed, never married. *Marital status* is a dichotomous measure indicating the respondent is married or living with a partner. *Employment status* was also assessed in each EMA wave by asking whether a respondent was: employed full-time; employed part-time, employed with some other arrangements, and not employed. Analyses include a dichotomous measure indicating any employment (reference: no employment).

We also considered household composition as a key variable, as it may be associated with both momentary context and loneliness. We constructed two measures indicating baseline co-residential status and household size using items that assess household membership of close network ties, as well as details on additional household members, if any. One dichotomous measure indicated whether respondents lived alone or not at baseline (40% live alone); a second continuous measure indicated household size at baseline (M=1.77, range 1–5). Household composition measures were moderately correlated with marital status (r=.50 and r=.44, respectively); because marital status varies across waves, and therefore provides a more accurate and up-to-date picture of respondents' regular social interactions, we present results from models including marital status. Additional models controlling for household measures yielded estimates of interest similar to those presented in the tables, with household measures having a negative and statistically and/or moderately significant effect on loneliness. Last, models predicting loneliness include a measure of respondents'

previous loneliness report. Additional models controlling for time between loneliness reports yield near identical results.

Analytic Sample

Of the 450 respondents who participated in the baseline interview, 379 went on to participate in at least one wave of EMAs (84% of baseline respondents) and the baseline interviews in waves 2 and 3. We excluded from analyses respondents (n=11) belonging to the "Other" race/ethnicity category (3% of respondents); given this study's focus on variation in loneliness across racial/ethnic groups, the low statistical power due to small cell sizes may lead to biased results. Therefore, we focus analysis on the largest racial/ethnic groups in the United States: non-Hispanic Whites, non-Hispanic Blacks, and non-Black Hispanics. Of the remaining 366 participants, 354 completed at least one ping (EMA): 77% completed at least one ping in wave 1; 77% in wave 2; and 64% for wave 3.

We then calculated the amount of time that elapsed from when participants began and when they submitted a survey (Hektner et al., 2007). Given that EMA responses are intended to be completed in real time, we excluded from analysis any pings that a participant took more than 30 minutes to complete (n = 363), as well as any pings that a participant did not begin within 30 minutes of the trigger time (n = 784). These criteria are somewhat more liberal than those of prior studies, which often exclude from analysis any EMAs that were filled out more than 20 minutes after the initial trigger was sent (Csikszentmihalyi & Larson, 2014). Excluding these ping responses reduces the potential for recall bias and also minimizes bias that could result from granting participants unlimited discretion in when they complete the assessments (Shiffman et al., 2008).

In cases where the MetricWire application mistakenly recorded an exact duplicate copy of a ping response (n = 23 redundant duplicates), we only analyzed one of each response. Any EMA response that was started or submitted less than 30 minutes within another EMA (n = 356) was not analyzed (Hektner et al., 2007). We also note that due to a programming error, at the start of wave three of EMA data collection, some participants (n = 40; 431 EMAs) were simultaneously enrolled in both waves two and three and received ping triggers for both waves on one or more days of participation (i.e., more than 5 pings/day rather than 5). These EMAs were included in analyses unless they fit the exclusion criteria detailed above. For example, a respondent who received two pings for Survey 1 on a given day, but submitted these as separate EMAs, at least 30 minutes apart and within 30 minutes of receiving the pings, would contribute two unique EMAs. Regarding specific measures, observations with missing loneliness and/or location data were dropped from our analyses (<1%; n=129 EMAs and 18 EMAs, respectively). We used a similar approach for missing key covariates because these contained very few missing cases (approximately 3.5% all EMAs): time-varying marital status (n=2 EMAs), education (n=3 EMAs), employment status (n=101 EMAs), age (n=32 EMAs), and self-reported physical health (n=346 EMAs). Importantly, missingness on any of these key measures was not strongly correlated with any of the socio-demographic, time-varying status (e.g., health, marital), context, or loneliness measures (rs range from 0.00 to 0.08). After implementing these criteria, we excluded

from analyses respondents that completed only one ping throughout the observation period (n=15), resulting in a final analytic sample of 12,793 EMAs across 342 respondents.

Analytic Approach

We utilize the longitudinal nature of the data and model older adults' reports of loneliness by fitting multilevel linear regression models that adjust for the clustering of reports of momentary loneliness (EMAs; level 1) within individuals (respondents; level 2) over time. We test the effects of social and physical context on momentary loneliness (RQ 1b). For each model, a hierarchical linear model defining two levels is estimated as follows: i for a given EMA; and j for a given respondent. The models are specified as follows:

$$\text{Level 1: } Y_{ij} = \beta_{0j} + \beta_1 X_{1ij\ldots} + \beta_k X_{kij} + e_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{01} W_j + \gamma_{00} + u_{oj}$$

In the Level 1 equation, Y_{ij} is the predicted value of reported loneliness in EMA i submitted by respondent j; β_{0j} are respondent-specific intercepts; e_{ij} is the error term; β_1 - β_j are the effects parameters of the explanatory context, key time-varying covariates (e.g., physical and social context, marital and health status), and a respondent's previous loneliness report; and X_{1ij} — X_{jit} are these variables in the model. In the Level 2 equation, γ_{00} represents the respondent-level intercept, u_{0j} is the respondent-level error term, and W_j and γ_{01} are fixed effects and time-invariant covariates at Level 2 (e.g., race/ethnicity and gender), respectively.

Next, for models testing whether specific demographic groups are differentially exposed to key physical and social contexts (e.g., home, alone; RQ 2a), we use similar multilevel models, although the outcome is the log-odds of being exposed to the respective context. Last, for models testing whether demographic characteristics (Level 2) modify the associations between context and loneliness (Level 1; RQ 2b), we use similar models discussed above and include cross-level interaction terms between demographic characteristics and context, where b_m are the effects parameters of the interaction between two explanatory variables (e.g., location and gender) and $X_{it1}X_{it2}$ are the corresponding interaction variables. These cross-level interaction models include random slopes for gender and/or race/ethnicity. For all models, a positive coefficient indicates a more intense feeling of loneliness (RQs 1a, 1b, and 2b) and higher log-odds of experiencing a particular context (RQ 2a). We present estimates from the fixed effect portion of the model as well as multiple variance components: Level 1 (EMA) and Level 2 (respondent) variance, ICC (for the null model only), the log likelihood, and the Pseudo R^2, the latter of which is calculated using the squared correlation between observed and predicted loneliness scores and excluding the error terms. All study analyses were conducted using STATA software Version 16. Statistical significance for all analyses was set at $p < .05$.

Multivariate models also include a version of participants' reported loneliness in the last EMA they submitted due to the autocorrelation between respondents' responses. Additional models controlling for a time-varying number of surveys completed at the time a participant

was responding to an EMA; timing of EMA (i.e., survey window, day of week, season); and for residential neighborhood at baseline yielded similar results.

Results

Descriptive Statistics: Intensity and Variation in Momentary Loneliness

Table 1 presents baseline descriptive statistics at the respondent level (*N*=342). About half of the sample identified as Black, with fewer identifying as White and Hispanic, respectively. Educational attainment was approximately evenly distributed across each of the four assessed levels (range of 20–28% per group). A majority of respondents were female, did not have a spouse/cohabiting partner, were unemployed, and lived alone (household size ranged from 1–5 people). Respondents most often reported having good health, and the average age of respondents was 74 years at baseline (range of 65–97 years).

Regarding physical context at the EMA-level (*N*=12,793; Table 1), respondents were at home nearly three-fourths of the time and were less often in transit, at work, or someplace else. In terms of social context, just over half of the EMAs were completed when respondents were alone. When not alone, respondents most often reported being with a family member, followed by a spouse/partner, friend, pet, and/or someone else.

Overall, among our analytic sample of 342 respondents (described above), respondents answered an average of 37.8 EMAs (range 2–116) across the three waves of data collection. The total response rate was about 36% valid EMAs out of all possible EMAs (i.e., out of 35,910 EMAs). The conditional response rate was 50% for wave 1, 52% for wave 2, and 47% for wave 3. Likelihood of non-response was not strongly correlated with any of the socio-demographic, time-varying status (e.g., health, marital), context, or loneliness measures (*r*s range from 0.00 to 0.08).

Bivariate Statistics *(Research Questions 1a and 1b)*

At the respondent level, individuals had a mean score of loneliness of 1.20, or between *not at all* and *slightly.* This was similar across waves, with means of 1.17, 1.20, and 1.21 in Waves 1, 2, and 3, respectively. Importantly, while means in loneliness were low, 53% of respondents experienced some level of loneliness (i.e., *slightly, moderately, or very)* at some point during the study, with 36 respondents reporting being *very lonely* at some point. Only 2 respondents reported some level of loneliness in all EMAs, suggesting few individuals experience “chronic” loneliness. Rather, nearly all respondents report transient or acute bouts of loneliness, underscoring the importance of examining individual variation in momentary loneliness.

Table 1 presents patterns in loneliness across demographic groups (respondent level; top-most rows) and across physical and social contexts (EMA-level; lower-most rows). Men showed higher mean loneliness than women, and mean loneliness differed by health status: Those with fair/poor health were lonelier than those who reported good or excellent/very good health. Respondents who lived alone and were not married or cohabiting with a partner at baseline were also lonelier than those who lived with at least one other person and who

were married, respectively. Average loneliness did not differ significantly by race/ethnicity, educational attainment, or employment status.

With regard to momentary physical context, EMAs in which respondents reported being at home or someplace else had the highest levels of loneliness (i.e., most intense), followed by in transit and at work; loneliness differed significantly across these locations. Regarding social context, respondents who were alone showed higher average loneliness than those who were not alone. In addition, respondents had the lowest levels of loneliness when with a spouse/partner or pet and highest when with a family member, a friend, or other. Because these particular groups are not mutually exclusive, no statistical tests of significance were conducted.

Multivariate Models

Demographic Characteristics (Research Question 1a)—We next move to test the associations between context and loneliness in a multivariate model, with Model 1 in Table 2 presenting results from a null multilevel linear regression model. The intraclass-correlation (ICC) for this model is 0.54, which suggests that 54% of the variation in loneliness can be explained by between-respondent variance and justifies the use of multilevel models. Model 2 in Table 2 presents results from a similar model but includes key socio-demographic characteristics. When controlling for all other covariates, reported loneliness was higher among men (vs. women), not married/cohabiting with a partner respondents (vs. married/cohabiting), and respondents with some high school education (vs. a college degree or higher). Regarding model diagnostics, the Pseudo R^2 is .34, which indicates variance in loneliness is explained by the inclusion of socio-demographic predictors in the model compared to the null model. EMA-level variation is higher than respondent-level variation, with the latter being much smaller than that presented in Model 1. Additional models including random slopes for gender and/or race/ethnicity yield similar results, with minimal model improvement.

Physical and Social Context (Research Question 1b)—We next turn to models to estimate the effects of time-varying context on momentary loneliness, net of demographic characteristics. Models 3–5 in Table 2 present results from multilevel models of the relationship between physical (Model 3) and social context (Models 4 and 5) and loneliness reports, adjusting for socio-demographic and time-varying status characteristics (e.g., health, marital). Models again include the previous report of loneliness to account for autocorrelation between reports.

Regarding location, relative to being at home, respondents currently at work, in transit, or someplace else reported lower levels of loneliness (Model 3), with work having the largest effect size. Regarding social context, those who were alone reported higher levels of loneliness than those who were not alone (Model 4). Being with family, friends, or other persons were each associated with lower levels of loneliness versus being alone (Model 5); being with a spouse/partner was not associated with lower loneliness. Both EMA- and respondent-level variation in Models 3–5 are similar to those in Model 2. The Pseudo R^2 is

also similar to that in Model 2, suggesting roughly the same amount of variance is explained in these models as was explained in Model 2.

Across all models in Table 2, the main effect of female gender remains robust: net of current physical and social context, women report lower levels of loneliness than men do. Other socio-demographic and time-varying status variables remain consistent with those presented in Model 2: Those currently married/cohabiting with a partner and those with at least a college degree report lower levels of loneliness than do their counterparts.

Differential Exposure to Contexts by Gender and Race/Ethnicity (Research Question 2)—Next, we move to test whether older adults from different gender and racial/ethnic groups are differentially exposed to physical (at home) and social (alone) contexts associated with high likelihoods of experiencing loneliness. Table 3 presents results from multilevel logistic regression models predicting respondents' likelihood of momentarily being at home (left-most model) and being alone (right-most model). Net of other key factors, compared to White respondents, Black respondents were more likely to be at home (left-most model) and Hispanic respondents were more likely to be alone (right-most model). No differences in likelihood existed by gender for either being home or alone. Respondents' likelihood of being home increased as their health declined, and those with some high school education were more likely to be at home than those with some college education. Finally, married/cohabiting with partners respondents were less likely to be alone, and older respondents were more likely to be at home and marginally less likely to be alone than their counterparts.

Gender and Race/Ethnicity Modifying Contextual Effects (Research Question 3)—Last, we test whether the adverse effects (i.e., experiencing a greater intensity of loneliness) of physical (at home) and social (alone) contexts shape loneliness differently by gender and/or race/ethnicity using a cross-level interaction model. Models 1a and 1b in Table 4 present results for multilevel linear regression models testing the effect of *being home* by gender (Model 1a) and by racial/ethnic groups (Model 1b); Models 2a and 2b show results from similar models testing the effects of *being alone* by gender and race/ethnicity, respectively. As noted above, these models include random slopes for gender or race/ethnicity. Across all models, relative to being outside the home and being with others, the respective main effects of being at home and being alone are consistent with those presented in Table 2: Both contexts are associated with higher levels of loneliness. When it comes to the adverse effect of being at home, however, differences exist across both gender and race/ethnicity. Specifically, when at home, women report being significantly less lonely than men (Model 1a). Results in Model 1b suggest that the adverse main effect of being at home is also smaller for Black and Hispanic respondents than it is for White respondents.

Next, the effect of being alone, relative to being with someone else, varies by gender: This adverse effect is smaller for women than it is for men (Model 2a). However, the effect of being alone does not differ across racial/ethnic groups (Model 2b). Other key variables operate in similar directions to those presented in Table 3. Both EMA- and respondent-level variances are also similar to those in Table 3.

Additional analyses combine the effects of being home and of being alone into one cross-level linear regression model to further tease apart the race/ethnicity effects presented in Tables 3 (Black respondents more likely to be at home and Hispanic respondents more likely to be alone) and 4 (both groups experience being at home differently than White respondents). We create a categorical variable using these two context measures: at home and alone (reference), with indicators for being (1) at home and not alone, (2) not at home and alone, and (3) not at home and not alone. We regress loneliness onto this measure, accounting for the same key covariates included in previous models in Tables 2–4. Results from this model (Supplementary Table 1, Model 1) suggest that, relative to being at home and alone, all three other contextual combinations are associated with lower levels of momentary loneliness, as expected. However, interactions with race/ethnicity show that Black respondents experience significantly more loneliness outside the home—regardless of whether they are or are not with others—than do White respondents. To ease interpretation, we present the average marginal effects of loneliness across social and physical contexts by race/ethnicity in Figure 2b. Relative to being home and alone, racial/ethnic groups do not differentially experience loneliness when they are home but not alone (they all report being less lonely). However, they *do* differ when it comes to being *outside* the home: White respondents report less loneliness in both social contexts when outside the home, whereas Black respondents report more loneliness when alone, and to a smaller extent, less loneliness when with others.

In another multilevel linear regression (Supplementary Table 2), we follow the same approach as above (Supplementary Table 1, Model 2), but interacting the home/alone context variable with gender, rather than race/ethnicity. As depicted in Figure 2a, these results reveal that relative to being home and alone, women are significantly lonelier than men when they are not alone, regardless of whether they are home or not home.

Discussion

Prior research has identified older adults, women, and—although less conclusive—Black adults as being at higher risk for loneliness than their counterparts. Separate studies that consider social and physical context have shown that individuals with less robust networks (i.e., smaller or weaker ties) and those who live in more disadvantaged neighborhoods also report more loneliness. However, little is known about how those of different genders and racial/ethnic groups may experience social and physical contexts differently in terms of their momentary loneliness, and the extent to which these differences may be explained by differential exposure or reactivity to such contexts. The present investigation fills this gap in the literature, harnessing rich EMA data to examine shorter-term changes in momentary loneliness within respondents.

We began by assessing patterns in momentary loneliness and how these relate to gender, race/ethnicity, as well as social and physical context. First, although respondents' reports skewed in general toward *not at all* and *slightly* lonely, momentary experiences with loneliness are relatively common among older adults: Over half of respondents (52%) felt at least *slightly* lonely at least once during the study. In addition, these respondents reported varying levels of momentary loneliness across the study: Nearly 20% reported each possible

response option for the loneliness item (i.e., ranging from *not at all* to *very much)* at least once during the study. These findings highlight the unique value of EMA loneliness assessments and suggest that previously utilized one-time assessments fail to capture the full story.

Second, variation in the intensity of momentary loneliness was associated with both momentary context and demographic characteristics. Those who were momentarily at home or alone were more likely to report feeling lonely, which is consistent with existing EMA literature. Regarding socio-demographics, men, those without a spouse/partner, and those with less than a high school degree were more likely to report feeling lonely than their counterparts, net of other key factors. These findings are somewhat consistent with the existing trait-like (i.e., between-subjects) literature, although diverge in the case of gender (Hawkley et al., 2019; Pinquart & Sorensen, 2001) and, to some extent, race/ethnicity. Some prior research (Nicolaisen & Thorsen, 2014; Shiovitz-Ezra & Ayalon, 2011) has found that men and women differ in their reports of loneliness depending on the relative directness of the measure employed, such that loneliness is more prevalent among women when a more direct measure is used and more prevalent among men when an indirect scale such as the UCLA Loneliness Scale (Russell, 1996) or the De Jong Gierveld Scale (De Jong-Gierveld & Kamphuls, 1985) is used. However, the present study utilized a single-item direct assessment, and men exhibited greater loneliness than women. Differing findings may also relate to differing measurement time scales; the present study captures momentary loneliness, whereas other studies do not provide a time frame at all (Hawkley et al., 2019). Further research using EMAs in this population may shed light on whether the momentary versus trait-like assessment of loneliness may be a factor contributing to differential endorsements of loneliness among older adult men and women. In addition, whereas the current study assessed loneliness intensity, some prior research has asked about the frequency of such feelings (Hawkley et al., 2020). Women may be more likely to report frequent loneliness, regardless of intensity (i.e., a lower threshold), whereas men may be less likely to report loneliness unless relatively intense. This hypothesis remains a question for future research.

Third, results suggest that women's reported lower intensity of momentary loneliness is not likely due to their higher or lower likelihood of experiencing loneliness-inducing contexts compared to men (e.g., being at home or being alone). Rather, this strong gender difference is due to women differentially responding to these contexts: They report being significantly less lonely when at home and alone than men do when they are in similar contexts. Our supplementary analysis suggested that for women, the social context mattered more than the physical: Women were lonelier than men when they were with others, regardless of whether they were home or not. We conjecture that compared to older men, older women could be using the phone, social media, or other electronic communications more often with loved ones not living with them—a factor that may be related to lower loneliness among women than men when at home and/or (physically) alone. Although the CHART study did not assess use of remote modes of communication, their relative omnipresence in modern everyday life bears empirical consideration in investigations of loneliness. A second possibility is men's social dependence on their wives/partners for social connections, which in contrast to women, who tend to report more diverse social ties, such as friends or sisters

(Umberson et al., 1996). As result, men without partners are uniquely isolated and may feel this when alone more so than women do.

Regarding racial/ethnic differences, Black and Hispanic respondents did not differ in loneliness from Whites in general, despite their greater frequency of being home and being alone than White respondents. However, this lack of difference misses the nuance of momentary contexts. Specifically, both Black and Hispanic respondents, relative to those who are White, did not experience the adverse context of being at home as severely: White respondents reported being significantly more lonely while at home than did Black or Hispanic respondents, and this is net of marital status and, in additional analyses, baseline household composition—co-residential status (i.e., whether they live with anyone else) and household size. Conversely, Black respondents, in particular, reported being significantly more lonely *outside the home* than did White respondents, regardless of their momentary social context. Only by examining the interaction between race and physical context did a racial/ethnic difference in loneliness emerge. These results help explain unique sources of loneliness among Black and Hispanic respondents. Specifically, although their overall experiences with loneliness do not significantly differ from White respondents, Black respondents, in particular, are lonelier than Whites *under specific circumstances*—namely, when they are outside the home.

Future research may further examine whether the heightened loneliness experienced by Black versus White respondents outside of the home may be in part explained by the nature of the spaces in which they reside or visit. For example, perhaps outdoor spaces provide more opportunity for ameliorating loneliness for White versus Black older adults due to factors such as White respondents more often living in single-family dwellings or in neighborhoods where characteristics of the areas outside of the home differ in the amount and type of amenities offered (e.g., parks), the relative presence or absence of violence, and social norms regarding how individuals in the community interact with one another. In addition, experienced and/or anticipated discrimination (Lee et al., 2019) may be factors linked with elevated loneliness among Black relative to White older adults in public (Sutin et al., 2015).

Although beyond the scope of the present investigation, the potential modifying impact of perceived outdoor neighborhood characteristics on loneliness may be explored using existing data from CHART; respondents also self-reported perceived characteristics of the momentary space they occupied (e.g., whether it felt like a close-knit, trustworthy, clean, or crowded space) and any people momentarily around them (e.g., people smiling and saying “hello,” racial/ethnic tension, or police using excessive force). The present study examined the effects of the individuals respondents were personally with at a given moment, but additional insights may be gleaned by also examining who else was momentarily in the respondent’s surroundings (e.g., the number of other people the respondent knew or recognized, and the extent to which these people were of different ages, races, or ethnicities —factors included in the CHART dataset). Perceptions of social cohesion (Kawachi & Berkman, 2000) in the broader neighborhood context—that is, the strength of relationships and the sense of solidarity among members of a community—may also plausibly influence feelings of loneliness in public spaces.

In sum, the findings reported here highlight which groups of older adults are at elevated risk of experiencing momentary loneliness and in which social and physical contexts—information that may be used to inform future just-in-time adaptive loneliness interventions (Nahum-Shani et al., 2017). For example, researchers might utilize respondents' GPS location data or EMA ping response data to initiate momentary interventions when older adults are alone or at home. Additional research is needed to determine the most appropriate intervention under these contexts, although simply alerting individuals to their heightened risk for loneliness in certain contexts could prompt their moving to a different, more beneficial context. The feasibility of such an approach could be explored using the CHART data to address whether naturally occurring changes in physical or social context are accompanied by changes in loneliness.

More generally, although this study isolates real-time contextual effects, it does not examine how specific groups navigate or make choices about these contexts. For example, Black respondents may choose to spend more time at home given their adverse experiences outside the home. Relatedly, prior literature suggests that specific characteristics associated with neighborhoods (e.g., disorder and community trust) may influence individuals' mental health through various mechanisms (Kawachi & Berkman, 2000). Future work should examine what exactly may be driving the adverse effects of being outside the home for Black and Hispanic respondents.

Limitations

A limitation of this study is that the results may not be generalizable to older adults in other contexts beyond Chicago, such as those living in rural areas, areas with less racial/ethnic diversity, or areas where neighborhood segregation by race/ethnicity is less prevalent. In addition, results may not generalize to those older adults who do not have any interest in using smartphones. However, smartphone access itself was not a barrier to participation; the study provided respondents with smartphones, along with instructions and guided practice on how to use them, and troubleshooting as needed over the course of the study. Another potential limitation is the response rate; on average, respondents completed about 50% of the total number of pings they were sent across all three waves of the study. Although this rate is lower than that of some other prior studies, this may be in part explained by the volume and frequency of pings that respondents received; response rates decrease as the number of pings per day increase (Christensen et al., 2003). The present study sent five pings per day across a total of 21 days. A notable mitigating factor is that response rates were not significantly associated with key variables of interest in this study. A final limitation is that this study relied on a single-item direct measure of loneliness. Although this approach can produce different estimates of loneliness than multi-item indirect measures (Shiovitz-Ezra & Ayalon, 2011), it does not invalidate the within-subject results reported in this paper, and other extant research has also utilized single-item loneliness assessments (Shiovitz-Ezra & Ayalon, 2011; Victor et al., 2005).

Conclusions

We conclude that repeated momentary data offer a unique and under-explored window into the daily lives of older adults and how daily physical and social contexts relate to feelings of loneliness. Strengths of this investigation include the recruitment of older adults from ten diverse Chicago neighborhoods of varying socioeconomic status and racial/ethnic composition, as well as the use of EMA to obtain randomly-timed snapshots of older adults' daily experiences, including rich contextual data that permit exploration into the pathways linked with loneliness. The present findings are among the first to identify contextual effects on real-time loneliness in older adults, their moderation by gender and race/ethnicity, and the identification of differential reactivity versus differential exposure as explanations for gender and racial-ethnic differences in momentary loneliness.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work was supported by the National Institute on Aging at the National Institutes of Health (5R01AG050605-05 to K.C.).

References

Cacioppo S, Capitanio JP, & Cacioppo JT (2014). Toward a neurology of loneliness. Psychological Bulletin, 140, 1464–1504. 10.1037/a0037618 [PubMed: 25222636]

Christensen TC, Barrett LF, Bliss-Moreau E, Lebo K, & Kaschub C (2003). A practical guide to experience-sampling procedures. Journal of Happiness Studies, 4, 53–78. 10.1023/A:1023609306024

Csikszentmihalyi M, & Larson R (2014). Validity and reliability of the experience-sampling method. Flow and the Foundations of Positive Psychology pp. 35–54. Dordrecht: Springer. 10.1007/978-94-017-9088-8_3

De Jong-Gierveld J, & Kamphuls F (1985). The development of a Rasch-type loneliness scale. Applied Psychological Measurement, 9, 289–299. 10.1177/014662168500900307

Dugan E, & Kivett VR (1994). The importance of emotional and social isolation to loneliness among very old rural adults. The Gerontologist, 34, 340–346. 10.1093/geront/34.3.340 [PubMed: 8076875]

Finlay JM, & Kobayashi LC (2018). Social isolation and loneliness in later life: A parallel convergent mixed-methods case study of older adults and their residential contexts in the Minneapolis metropolitan area, USA. Social Science & Medicine, 208, 25–33. 10.1016/j.socscimed.2018.05.010 [PubMed: 29758475]

Fokkema T, De Jong Gierveld J, & Dykstra PA (2012). Cross-national differences in older adult loneliness. The Journal of Psychology, 146, 201–228. 10.1080/00223980.2011.631612 [PubMed: 22303621]

Hawkley LC, Steptoe A, Schumm LP, & Wroblewski K (2020). Comparing loneliness in England and the United States, 2014–2016: Differential item functioning and risk factor prevalence and impact. Social Science & Medicine, 113467. 10.1016/j.socscimed.2020.113467 [PubMed: 33162196]

Hawkley LC, Wroblewski K, Kaiser T, Luhmann M, & Schumm LP (2019). Are U.S. older adults getting lonelier? Age, period, and cohort differences. Psychology and Aging, 34, 1144–1157. 10.1037/pag0000365 [PubMed: 31804118]

Hektner JM, Schmidt JA, & Csikszentmihalyi M (2007). Experience Sampling Method: Measuring the Quality of Everyday Life. Thousand Oaks, CA: Sage Publications.

Kawachi I, & Berkman LF (2000). Social Cohesion, Social Capital, and Health. In Berkman LF, & Kawachi I (Eds.), Social Epidemiology. New York, NY: Oxford University Press.

Kim J (2010). Neighborhood disadvantage and mental health: The role of neighborhood disorder and social relationships. Social Science Research, 39, 260–271. 10.1016/j.ssresearch.2009.08.007

Larson RW (1990). The solitary side of life: An examination of the time people spend alone from childhood to old age. Developmental Review, 10, 155–183. 10.1016/0273-2297(90)90008-R

Lee RT, Perez AD, Boykin CM, & Mendoza-Denton R (2019). On the prevalence of racial discrimination in the United States. PloS One, 14, e0210698. 10.1371/journal.pone.0210698 [PubMed: 30629706]

Long MV, & Martin P (2000). Personality, relationship closeness, and loneliness of oldest old adults and their children. The Journals of Gerontology Series B: Psychological and Social Sciences, 55, P311–P319. 10.1093/geronb/55.5.P311

Luhmann M, & Hawkley LC (2016). Age differences in loneliness from late adolescence to oldest old age. Developmental Psychology, 52, 943–959. 10.1037/dev0000117 [PubMed: 27148782]

Moore RC, Depp CA, Wetherell JL, & Lenze EJ (2016). Ecological momentary assessment versus standard assessment instruments for measuring mindfulness, depressed mood, and anxiety among older adults. Journal of Psychiatric Research, 75, 116–123. 10.1016/j.jpsychires.2016.01.011 [PubMed: 26851494]

Nahum-Shani I, Smith SN, Spring BJ, Collins LM, Witkiewitz K, Tewari A, et al. (2017). Just-in-time adaptive interventions (JITAIs) in mobile health: Key components and design principles for ongoing health behavior support. Annals of Behavioral Medicine, 52, 446–462. 10.1007/s12160-016-9830-8

National Academies of Sciences, Engineering, and Medicine. (2020). Social Isolation and Loneliness in Older Adults: Opportunities for the Health Care System. Washington, DC.

Nicolaisen M, & Thorsen K (2014). Who are lonely? Loneliness in different age groups (18–81 years old), using two measures of loneliness. The International Journal of Aging and Human Development, 78, 229–257. 10.2190/AG.78.3.b [PubMed: 25265679]

Ong AD, Uchino BN, & Wethington E (2016). Loneliness and health in older adults: A mini-review and synthesis. Gerontology, 62, 443–449. 10.1159/000441651 [PubMed: 26539997]

Peplau LA, & Perlman D (1982). Loneliness: A Sourcebook of Current Theory, Research and Therapy. New York, USA: Wiley & Sons.

Pinquart M, & Sorensen S (2001). Influences on loneliness in older adults: A meta-analysis. Basic and Applied Social Psychology, 23, 245–266. 10.1207/S15324834BASP2304_2

Ross CE, Mirowsky J, & Pribesh S (2001). Powerlessness and the amplification of threat: Neighborhood disadvantage, disorder, and mistrust. American Sociological Review, 66, 568–591. 10.2307/3088923

Russell DW (1996). UCLA Loneliness Scale (Version 3): Reliability, validity, and factor structure. Journal of Personality Development, 66, 20–40. 10.1207/s15327752jpa6601_2

Shiffman S, Stone AA, & Hufford MR (2008). Ecological momentary assessment. Annual Review of Clinical Psychology, 4, 1–32. 10.1146/annurev.clinpsy.3.022806.091415

Shiovitz-Ezra S, & Ayalon L (2011). Use of direct versus indirect approaches to measure loneliness in later life. Research on Aging, 34, 572–591. 10.1177/0164027511423258

Stack S (1998). Marriage, family and loneliness: A cross-national study. Sociological Perspectives, 41, 415–432. 10.2307/1389484

Stafford M, Chandola T, & Marmot M (2007). Association between fear of crime and mental health and physical functioning. American Journal of Public Health, 97, 2076–2081. doi:10.2105/AJPH.2006.097154 [PubMed: 17901443]

Stevens N, & van Tilburg T (2010). Stimulating friendship in later life: A strategy for reducing loneliness among older women. Educational Gerontology, 26, 15–35. 10.1080/036012700267376

Sutin AR, Stephan Y, Carretta H, & Terracciano A (2015). Perceived discrimination and physical, cognitive, and emotional health in older adulthood. The American Journal of Geriatric Psychiatry, 23, 171–179. doi:10.1016/j.jagp.2014.03.007 [PubMed: 24745563]

Taylor HO, & Nguyen AW (2020). Depressive symptoms and loneliness among Black and White older adults: The moderating effects of race. Innovation in Aging, 4, 1–13. 10.1093/geroni/igaa048

Umberson D, Chen MD, House JS, Hopkins K, & Slaten E (1996). The effect of social relationships on psychological well-being: Are men and women really so different? American Sociological Review, 61, 837–857. 10.2307/2096456

Victor C, Grenade L, & Boldy D (2005). Measuring loneliness in later life: A comparison of differing measures. Reviews in Clinical Gerontology, 15, 63–70. doi:10.1017/S0959259805001723

Wu C, Barczyk AN, Craddock RC, Harari GM, Thomaz E, Shumake JD, et al. (2021). Improving prediction of real-time loneliness and companionship type using geosocial features of personal smartphone data. Smart Health, 20, 100180. 10.1016/j.smhl.2021.100180

Yavuz N, & Welch EW (2010). Addressing fear of crime in public space: Gender differences in reaction to safety measures in train transit. Urban Studies, 47, 2491–2515. 10.1177/0042098009359033 [PubMed: 20976976]

York Cornwell E, Cagney KA, & Hawkley LC (2019). Inequalities in social and physical contexts of older adults' activity spaces: Early results from the CHART study. Annual Meeting of the Population Association of America (PAA). Austin, TX. http://paa2019.populationassociation.org/uploads/193526

Zhaoyang R, Sliwinski MJ, Martire LM, & Smyth JM (2018). Age differences in adults' daily social interactions: An ecological momentary assessment study. Psychology and Aging, 33, 607–618. 10.1037/pag0000242 [PubMed: 29708385]

Highlights

- Ecological momentary assessments provide new insight into older adults' loneliness
- Being momentarily outside the home and/or not alone buffer against loneliness
- Protective effects were weaker for Black and Hispanic and for female respondents
- Differential reactivity, rather than exposure, may explain between-group variation
- Inform just-in-time adaptive loneliness interventions in older adulthood

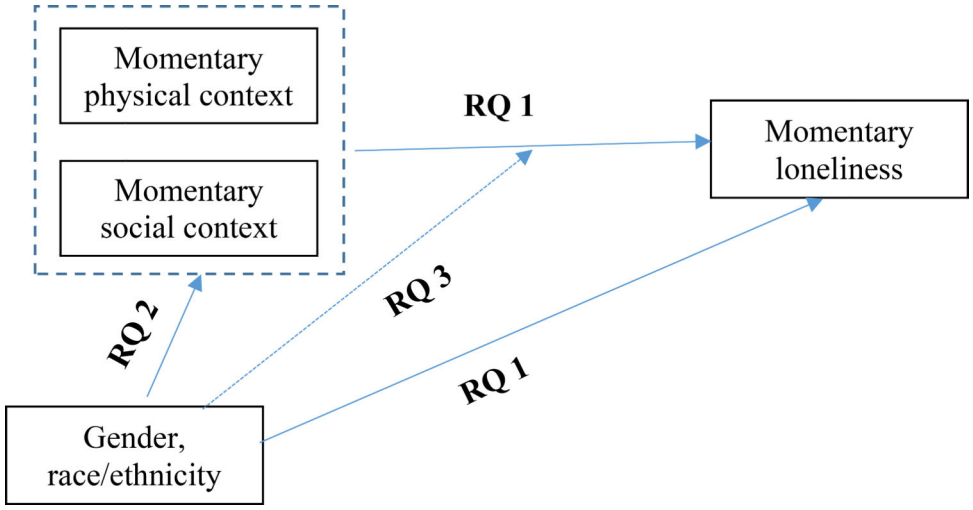

Figure 1.
Conceptual framework for key relationships of interest

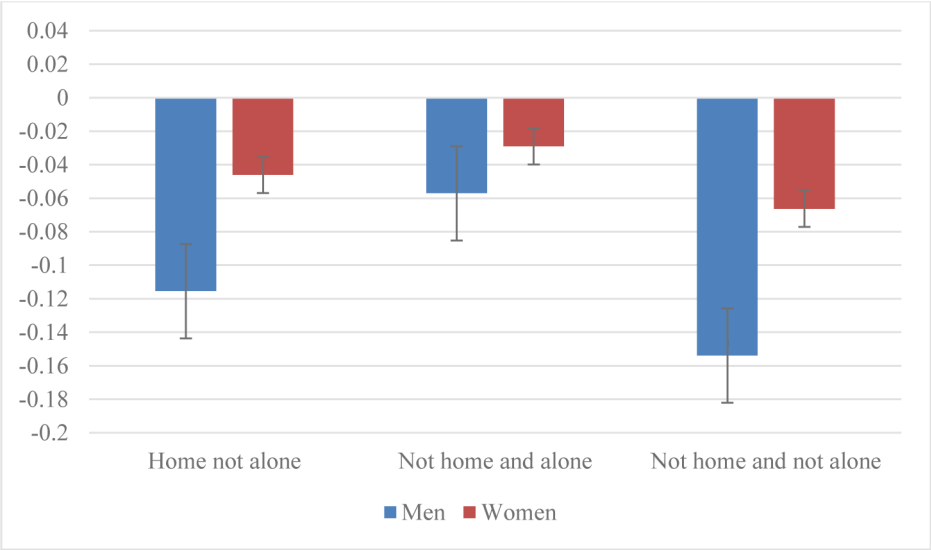

Figure 2a.

Average marginal effects of social and physical context on momentary reports of loneliness by gender (reference: being home and alone)

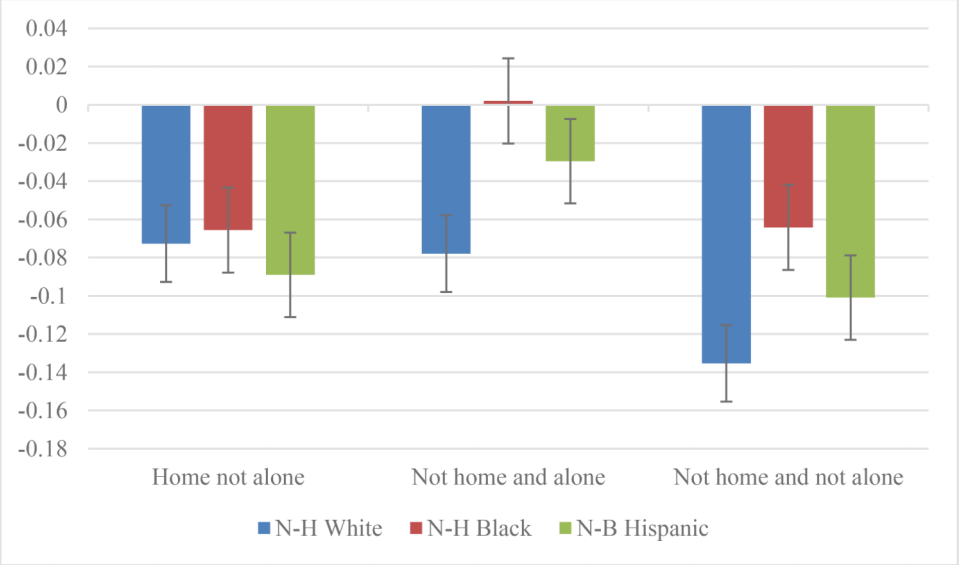

Figure 2b.

Average marginal effects of social and physical context on momentary reports of loneliness by race/ethnicity (reference: being home and alone)

Table 1.

Patterns in loneliness across sample characteristics and key EMA social and physical context (*n*=342; 12,793 EMAs)

Respondent-level (N=342)	**Demographic characteristics**	**Loneliness mean (range 1–4), within respondent**		
	Proportion or Mean (SD)	Mean	SD	*p*
Gender				***
Men	0.40	1.30	0.52	
Women	0.60	1.14	0.29	
Race/ethnicity				
Non-Hispanic White	0.27	1.20	0.37	
Non-Hispanic Black	0.51	1.21	0.42	
Non-Black Hispanic	0.22	1.20	0.40	
Education				
Less than high school	0.28	1.28	0.47	
High school	0.20	1.18	0.44	
Some college	0.24	1.21	0.39	
College +	0.28	1.15	0.27	
Self-reported health status (baseline)				***
Excellent/very good	0.37	1.11	0.20	
Good	0.41	1.21	0.40	
Fair/poor	0.23	1.32	0.54	
Marital status (baseline)				*
Not married	0.68	1.24	0.44	
Married	0.32	1.12	0.30	
Employment status (baseline)				
Employed, any	0.20	1.22	0.38	
Not employed	0.80	1.20	0.41	
Age	73.69			
Household composition (baseline)				
Live alone				*
Yes	0.59	1.28	0.49	
No	0.41	1.16	0.36	
Household size	1.77 (0.84)			
EMA-level (N=12,793)	**Real-time context**	**Loneliness means (range 1–4), by context**		
	%	Mean	SD	p
Physical context				***
Home	0.74	1.20	0.39	
At work	0.04	1.14	0.21	
In transit	0.09	1.18	0.33	
Someplace else	0.13	1.19	0.38	

Social context				
Alone				***
Yes	0.52	1.26	0.45	
No	0.48	1.13	0.27	
Who with (not mutually exclusive)				
Spouse/partner	0.14	1.07	0.19	
Family member	0.20	1.14	0.29	
Friend	0.09	1.15	0.29	
Pet	0.06	1.09	0.16	
Other	0.04	1.15	0.25	

Note. SD = standard deviation. Measures of loneliness are coded so that higher values are more lonely. Results are from t-tests and ANOVA tests of significance of group means.

* $p<.05$

** $p<.01$

*** $p<.001$.

Table 2.

Multilevel models reporting coefficients (standard errors) for loneliness regressed on demographic characteristics and context.

	Model 1	Model 2	Model 3	Model 4	Model 5
EMA-level					
Physical context (ref: home)					
At work			−0.11 ***		
			(0.02)		
In transit			−0.04 ***		
			(0.01)		
Someplace else			−0.04 ***		
			(0.01)		
Social context (ref: alone)					
Alone				0.07 ***	
				(0.01)	
Social context (ref: alone)					
Spouse/partner					−0.02
					(0.01)
Family					−0.07 ***
					(0.01)
Friend					−0.06 ***
					(0.01)
Pet					−0.02
					(0.02)
Other					−0.08 ***
					(0.02)
Health status (ref: excellent/very good)					
Good		0.01	0.01	0.01	0.01
		(0.01)	(0.01)	(0.01)	(0.01)
Fair/poor		0.00	−0.01	0.00	0.00
		(0.02)	(0.02)	(0.02)	(0.02)
Marital status					
Married/partnered		−0.06 *	−0.06 *	−0.05 *	−0.05 *

	Model 1		Model 2		Model 3		Model 4		Model 5	
			(0.02)		(0.02)		(0.02)		(0.02)	
Employment status										
Employed (any)			0.01		0.01		0.01		0.01	
			(0.04)		(0.04)		(0.04)		(0.04)	
Respondent-level										
Gender										
Female			−0.14	***	−0.14	***	−0.13	***	−0.13	***
			(0.04)		(0.04)		(0.03)		(0.03)	
Race (ref: Non-Hispanic White)										
Non-Hispanic Black			−0.02		−0.03		−0.02		−0.02	
			(0.04)		(0.04)		(0.04)		(0.04)	
Non-Black Hispanic			−0.06		−0.07		−0.07		−0.07	
			(0.05)		(0.05)		(0.05)		(0.05)	
Education (ref: less than high school)										
High school			−0.03		−0.03		−0.03		−0.03	
			(0.05)		(0.05)		(0.05)		(0.05)	
Some college			−0.05		−0.05		−0.05		−0.05	
			(0.05)		(0.05)		(0.05)		(0.05)	
College +			−0.10	*	−0.10	*	−0.10	*	−0.10	*
			(0.05)		(0.05)		(0.05)		(0.05)	
Age at baseline			0.00		0.00		0.00		0.00	
			(0.003)		(0.003)		(0.003)		(0.003)	
Previous loneliness report			0.23	***	0.23	***	0.23	***	0.23	***
			(0.01)		(0.01)		(0.01)		(0.01)	
Constant	1.20	***	1.30	***	1.35	***	1.24	***	1.30	***
	(0.02)		(0.20)		(0.20)		(0.20)		(0.20)	
Variance components										
EMA-level variance	0.13		0.14		0.13		0.13		0.13	
Respondent-level variance	0.16		0.08		0.08		0.08		0.08	
Additional information										

	Model 1	Model 2	Model 3	Model 4	Model 5
ICC	0.54				
Log likelihood	−5606.99	−5277.17	−5254.6	−5230.68	−5234.48
Pseudo R^2	0.00	0.34	0.33	0.34	0.34
Number of EMA observations	12451	12451	12451	12451	12451
Number of respondents	342	342	342	342	342

Note. Standard errors are presented below estimates. Measures of loneliness are coded so that higher values represent greater loneliness.

† p<.10

* p<.05

** p<.01

*** p<.001.

Table 3.

Multilevel models reporting log-odds (standard errors) for physical and social context exposures regressed on demographic characteristics

	Home		Alone	
EMA-level				
Health status (ref: excellent/very good)				
Good	0.14	†	0.12	
	(0.08)		(0.08)	
Fair/poor	0.28	**	−0.16	
	(0.11)		(0.11)	
Marital status				
Married/partnered	0.04		−0.79	***
	(0.12)		(0.15)	
Employment status				
Employed (any)	0.04		0.05	
	(0.16)		(0.25)	
Respondent-level				
Gender				
Female	0.13		−0.34	
	(0.14)		(0.21)	
Race (ref: Non-Hispanic White)				
Non-Hispanic Black	0.38	*	−0.35	
	(0.17)		(0.27)	
Non-Black Hispanic	−0.01		0.83	*
	(0.21)		(0.33)	
Education (ref: less than high school)				
High school	−0.10		−0.37	
	(0.20)		(0.31)	
Some college	−0.39	*	−0.33	
	(0.19)		(0.29)	
College +	−0.40	†	−0.32	
	(0.21)		(0.31)	

Soc Sci Med. Author manuscript; available in PMC 2022 September 01.

	Home		Alone	
Age at baseline	0.03	**	−0.03	†
	(0.01)		(0.02)	
Constant	−1.07		3.06	*
	(0.82)		(1.24)	
Respondent-level variance	1.00		2.99	
Additional information				
Log likelihood	−6597.88		−6876.59	
R^2	0.16		34.00	
Number of EMA observations	12793		12793	
Number of respondents	342		342	

Note. Standard errors are presented below estimates (in parentheses).

† p<.10

* p<.05

** p<.01

*** p<.001

Soc Sci Med. Author manuscript; available in PMC 2022 September 01.

Table 4.

Cross-level interaction models reporting coefficients (standard errors) for loneliness regressed on the interaction between context and demographic characteristics

	Home				Alone			
	Model 1a		**Model 1b**		**Model 2a**		**Model 2b**	
EMA-level								
Physical context								
Home (ref: outside the home)	0.07	***	0.08	***				
	(0.01)		(0.01)					
Social context								
Alone (ref: not alone)					0.12	***	0.08	***
					(0.01)		(0.01)	
EMA- x Respondent-level								
Home x female	−0.03	*						
	(0.02)							
Home x race (ref: Non-Hispanic White)								
Home x Non-Hispanic Black			−0.07	***				
			(0.02)					
Home x Non-Black Hispanic			−0.05	*				
			(0.02)					
Alone x female					−0.07	***		
					(0.02)			
Alone x race (ref: Non-Hispanic White)								
Alone x Non-Hispanic Black							−0.02	
							(0.02)	
Alone x Non-Black Hispanic							0.00	
							(0.02)	
Health status (ref: excellent/very good)								
Good	0.01		0.01		0.01		0.01	
	(0.01)		(0.01)		(0.01)		(0.01)	
Fair/poor	−0.01		−0.01		0.00		0.00	

	Home				Alone			
	Model 1a		**Model 1b**		**Model 2a**		**Model 2b**	
	(0.02)		(0.02)		(0.02)		(0.02)	
Marital status								
Married/partnered	−0.06	*	−0.06	*	−0.05	*	−0.05	*
	(0.02)		(0.02)		(0.02)		(0.02)	
Employment status								
Employed (any)	0.01		0.01		0.01		0.01	
	(0.04)		(0.04)		(0.04)		(0.04)	
Respondent-level								
Gender								
Female	−0.11	**	−0.14	***	−0.10	**	−0.13	***
	(0.04)		(0.04)		(0.04)		(0.03)	
Race/ethnicity								
Non-Hispanic Black	−0.03		0.03		−0.02		−0.01	
	(0.04)		(0.05)		(0.04)		(0.04)	
Non-Black Hispanic	−0.07		−0.03		−0.07		−0.08	
	(0.05)		(0.05)		(0.05)		(0.05)	
Education								
High school	−0.03		−0.03		−0.03		−0.03	
	(0.05)		(0.05)		(0.05)		(0.05)	
Some college	−0.06		−0.06		−0.05		−0.06	
	(0.05)		(0.05)		(0.05)		(0.05)	
College +	−0.03		−0.04		−0.03		−0.03	
	(0.05)		(0.05)		(0.05)		(0.05)	
Age at baseline	−0.05		−0.06		−0.05		−0.05	
	(0.05)		(0.05)		(0.05)		(0.05)	
Previous loneliness report	0.23	***	0.23	***	0.23	***	0.23	***
	(0.01)		(0.01)		(0.01)		(0.01)	
Constant	1.28	***	1.27	***	1.20	***	1.24	***
Variance components	(0.20)		(0.20)		(0.20)		(0.20)	

	Home		Alone	
	Model 1a	**Model 1b**	**Model 2a**	**Model 2b**
EMA-level variance	0.13	0.13	0.13	0.13
Respondent-level variance	0.08	0.08	0.08	0.08
Additional information				
Log likelihood	−5257.33	−5251.77	−5221.26	−5229.75
Pseudo R^2	0.35	0.35	0.34	0.34
Number of EMA observations	342	342	342	342
Number of respondents	12451	12451	12451	12451

Note. Standard errors are presented below estimates. Measures of loneliness are coded so that higher values represent greater loneliness.

* $p<.05$

** $p<.01$

*** $p<.001$.